Ab Initio Values of the Thermophysical Properties of Helium as Standards

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Recent quantum mechanical calculations of the interaction energy of pairs of helium atoms are accurate and they include reliable estimates of their uncertainty [Korona *et al*., *J. Chem. Phys.*, **106**:5109 (1997)]. We combined these recent *ab initio* results with earlier ones to obtain a helium-helium interatomic potential that includes relativistic retardation effects over all ranges of interaction. From this potential, we calculated the second virial coefficients, the viscosities, and the thermal conductivities of ^{3}He and of ^{4}He from 1 K to 2000 K and also the diffusion and thermal diffusion coefficients of mixtures of ^{3}He and ^{4}He. The calculations include quantum and symmetry effects. For these properties of low-density helium, the uncertainties of the calculated values are smaller than the corresponding experimental uncertainties. Therefore, we present our results in easy-to-use tabular form and recommend that they be used as standards for calibrating instruments used to measure these thermophysical properties of gases. This is a natural extension of our practice of using noble gases to calibrate acoustic resonators. In a similar fashion, the calculated dielectric constant of helium can be used as a standard for gas-filled capacitors and it may eventually lead to a pressure standard in the range 0.5 MPa to 5 MPa [M. R. Moldover, J. Res. Nat. Inst. Stds. Tech. **103**:167 (1998)].